The Role of Shallow Cloud Moistening in MJO and Non-MJO Convective Events over the ARM Manus Si

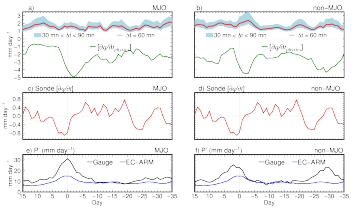
Research Highlight

Moistening by shallow clouds has been assumed to be partially responsible for the observed increase in low-level moisture leading to convective peaks of the Madden-Julian Oscillation (MJO). In this study, we move beyond the argument for the moistening role of shallow clouds in the MJO that is simply based on simultaneous increases in both low-level moisture and abundance of shallow clouds. We strove to quantitatively estimate shallow cloud moistening in the MJO.

We used observations from the Atmospheric Radiation Measurement (ARM) Climate Research Facility site at Manus Island to quantify bulk shallow cloud moistening through evaporation of condensed water using a simple method based on observations of liquid water path, cloud depth and temporal fraction, and surface rain rates. These estimates are compared to local moisture tendencies from soundings and by the circulation from re-analysis products. In addition, to investigate the uniqueness of the role of shallow cloud moistening in the MJO, we compared these moisture tendencies during MJO and non-MJO large-scale convective events at Manus.

Our results show positive tendencies in low-level moistening (Fig. 1 c, d) before rainfall peaks of MJO and non-MJO events (Fig. 1 e and f). Before and after the rainfall peaks, precipitating and nonprecipitating shallow clouds exist all the time, but their occurrence fluctuates randomly. Their contributions to moisture tendencies through evaporation of condensed water are evident (Fig. 1 a, b), but cannot be directly associated to the total low-level moistening leading to rainfall peaks in either type of event. Consistently, the physical moisture tendencies from reanalysis cannot either be associated to the positive moistening towards the rainfall peaks (Fig. 1 a, b). They are dominated by drying from precipitation. A moisture budget analysis over Manus shows that moisture increase is mainly caused by anomalous nonlinear zonal advection.

Although the effects of shallow clouds cannot be directly associated to low-level moisture increases prior the rainfall peaks of the MJO at Manus, moistening by these clouds is important because they provide background moistening to the lower troposphere.



Composites of daily (a),(b) moistening from nonprecipitating and precipitating shallow clouds combined (red lines for #t = 60 min, shaded areas for #t = 30-90 min); the physical moisture tendency from EC-ARM (#q/#t physics) and the (c),(d) moisture tendencies from the soundings (#q/#t) vertically integrated (denoted as square brackets) over the lower troposphere (0.1–4.5 km); and (e),(f) total rain rates from gauges and EC-ARM for (left) MJO and (right) non-MJO events at Manus Island.

Reference(s)

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Working Group(s)
Cloud Life Cycle